

# Presentation at the Fourth Plenary Meeting of the Advisory Committee on Acoustic Impacts on Marine Mammals

30 November-2 December 2004

New Orleans, Louisiana

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# Marine Mammal Populations and Ocean Noise:

Determining when noise causes  
biologically significant effects

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with support from:
  - National Oceanic and Atmospheric Administration
  - Office of Naval Research
  - National Science Foundation
  - Minerals Management Service.

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# Statement of Task

In its 2000 report, *Marine Mammals and Low-frequency Sound*, the National Research Council recommended that the Marine Mammal Protection Act definition of “Level B harassment should be limited to meaningful disruption of biologically significant activities that could affect demographically important variables such as reproduction and longevity.” Recognizing that the term “biologically significant” is increasingly used in resource management and conservation plans, this study will further describe the scientific basis of the term in the context of marine mammal conservation and management related to ocean noise.

# Statement of Task - continued

Based on input from a scientific workshop, consideration of the relevant literature, and other sources, the committee will produce a brief report that reviews and characterizes the current scientific understanding of when animal behavior modifications induced by transient and non-transient ocean acoustic sources, individually or cumulatively affect individuals in ways that have negative consequences for populations.



# Statement of Task

In its 2000 report, *Marine Mammals and Low-frequency Sound*, the National Research Council recommended that the Marine Mammal Protection Act definition of “Level B harassment should be limited to **meaningful** disruption of **biologically significant** activities that could affect demographically important variables such as reproduction and longevity.” Recognizing that the term “biologically significant” is increasingly used in resource management and conservation plans, this study will further describe the scientific basis of the term in the context of marine mammal conservation and management related to ocean noise.

# Biologically Significant

- Biologically significant habitats
- Biologically significant pharmacological responses
- Biologically significant for marine mammals
  - Biologically significant at the level of the individual or the population
  - Significant to individuals when affecting vital rates—reproduction and longevity
  - Significant to populations when the vital rates of many individuals are affected

## Statement of Task - Rephrased

Determining when human activity elicits behavioral or physiological responses in individual marine mammals that rise to the level of biological significance for the population.

# Biologically Significant

- Based on the recent history of the population and its environment
  - Changes that would be insignificant in normal circumstances can become significant in abnormal circumstances—e.g., during an El Niño
  - Changes that would be insignificant in a population near carrying capacity become significant in a depleted population

# Is Noise Significant?

- No evidence that anthropogenic noise has had a significant impact on any marine mammal population
- Significant declines not attributed to noise
  - Steller sea lions
  - Southwest Alaskan and California sea otters
  - Alaskan harbor seals

# Does Noise Have Significant Effects on Beaked Whale Populations?

- Beaked whale population sizes are unknown
- Effects on whales that do not strand are unknown
- Are the observed effects of noise on beaked whales the tip of the iceberg of a significant ocean issue?
- Is noise ever more than a second order effect?

# Conflict is Inevitable and Should be Minimized

- Humans and marine mammals use sound for the same reason: communication and environmental monitoring are more effective over longer ranges with sound than with other modalities
- Human technology-driven and marine mammal evolutionary-driven use of sound in the marine environment will inevitably lead to conflict

# Committee Could Provide No Eureka Moment

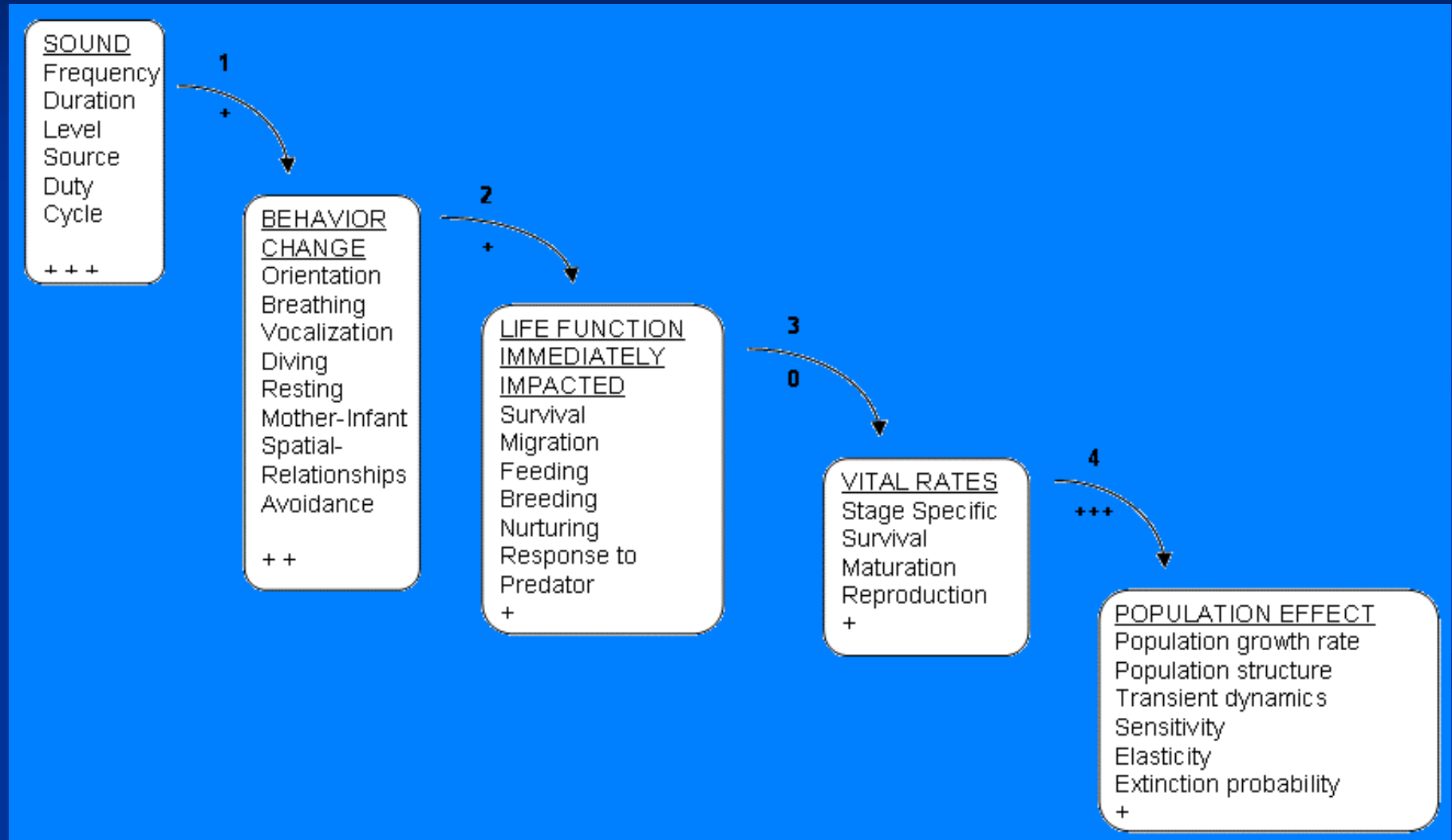
Changes in behavior that lead to alterations in foraging efficiency, habitat abandonment, declines in reproduction, increases in infant mortality, and so on, are difficult to demonstrate in terrestrial animals, including humans, and are much more difficult for animals that may only rarely be observed in their natural environment.



# Three Stage Approach

- Conceptual Model that will take a decade or more to convert into a Predictive Model
- Extension of the Potential Biological Removal Model to include sub-lethal “takes” from noise (will take years to complete)
- Development of web-based intelligent system to determine a *de minimis* threshold below which impacts of activities are clearly not significant (initial version within a year)

# Population Consequences of Acoustic Disturbance Model



# RECOMMENDATION 1

The high-priority research identified by the National Research Council (1994, 2000, 2003b) should be completed. That research is essential for the model proposed in this report.

## RECOMMENDATION 2

A conceptual model, such as that described in this report, should be developed more fully to help to assess impacts of acoustic disturbance on marine mammal populations. Development of such a model will allow sensitivity analysis that can be used to focus, stimulate, and direct research on appropriate transfer functions.

# RECOMMENDATION 3 (part I)

To assist in the development of the conceptual model, a centralized database of marine mammal sightings and their responses to anthropogenic sound in the ocean should be developed and should include

- Published peer-reviewed papers in the scientific literature.
- Government technical reports.
- Data submitted to NOAA Fisheries and the US Fish and Wildlife Service in permit applications.
- Data submitted by industry to the Minerals Management Service for regulating off-shore hydrocarbon exploration and production.
- All relevant data accumulated by all federal agencies in the course of their research and operational activities.

## RECOMMENDATION 3 (part II)

To facilitate the integration of data from the various sources, federal agencies need to develop standardized data-reporting formats. Survey data should include locations where marine mammals were detected and the track lines when personnel were monitoring for marine mammals, regardless of whether any were sighted. All data entered into such an integrated database must be coded as to quality, and peer-reviewed data and interpretations should be rated highest.

# RECOMMENDATION 4

The use of glucocorticoid and other serum hormone concentrations to assess stress should be developed, validated, and calibrated for various marine mammal species and age-sex classes and conditions.

Dose-Response curves for those indicators as a function of sound characteristics need to be established.

Development of a sampling package that could take blood samples on a controlled basis and stabilize hormones for later analysis or process samples “on-board” for corticosteroids at various stages of a CEE would be invaluable for determining the stress that the sound is producing.

The use of fecal sampling to measure condition or stress needs to be investigated further and developed.

Research efforts should seek to determine whether reliable long-term stress indicators exist and, if so, whether they can be used to differentiate between noise-induced stress and other sources of stress in representative marine mammal species (this recommendation was also made in NRC, 2003b).



# RECOMMENDATION 5

Several marine mammal species for which there are good long-term demographic and behavioral data on individuals should be selected as targets of an intensive exploratory modeling effort that would develop a series of individual-based models and stage- or age-structured demographic models for the species as appropriate.

NOAA Fisheries should bring together an independent, interdisciplinary panel of modelers and relevant empirical scientists that would meet periodically to pursue the modeling effort collaboratively in an iterative and adaptive manner with the long-term goal of developing tools to support informed, practical decision-making.



# RECOMMENDATION 6

A practical process should be developed to help in assessing the likelihood that specific acoustic sources will have adverse effects on a marine mammal population by disrupting normal behavioral patterns. Such a process should have characteristics similar to the Potential Biological Removal model, including

- Accuracy
- Encouragement of precautionary management—that is more conservative (smaller removal allowed)—when there is greater uncertainty in the potential population effects of induced behavioral changes
- Being readily understandable and defensible to the public, legal staff, and Congress
- An iterative process that will improve risk estimates as data improve
- Ability to evaluate cumulative impacts of multiple low-level effects, and
- Construction from a small number of parameters that are easy to estimate

# PBR as a successful model for regulating cumulative impacts

- Used now to regulate fisheries
- Initial regulatory regime simply requires fisheries to register, accept observers, and report serious injury and mortality
- Tallies all serious injury and mortality from fisheries
- If these exceed an acceptable level defined by PBR, a take reduction team is established

# Potential Biological Removal

$$\text{PBR} = N_{\min} * 0.5 * R_{\max} * F_r$$

$N_{\min}$  is the minimum population estimate

$R_{\max}$  is the maximum population growth rate

$F_r$  is a recovery factor ranging from 0.1 to 1.0

# PBR Management Goals

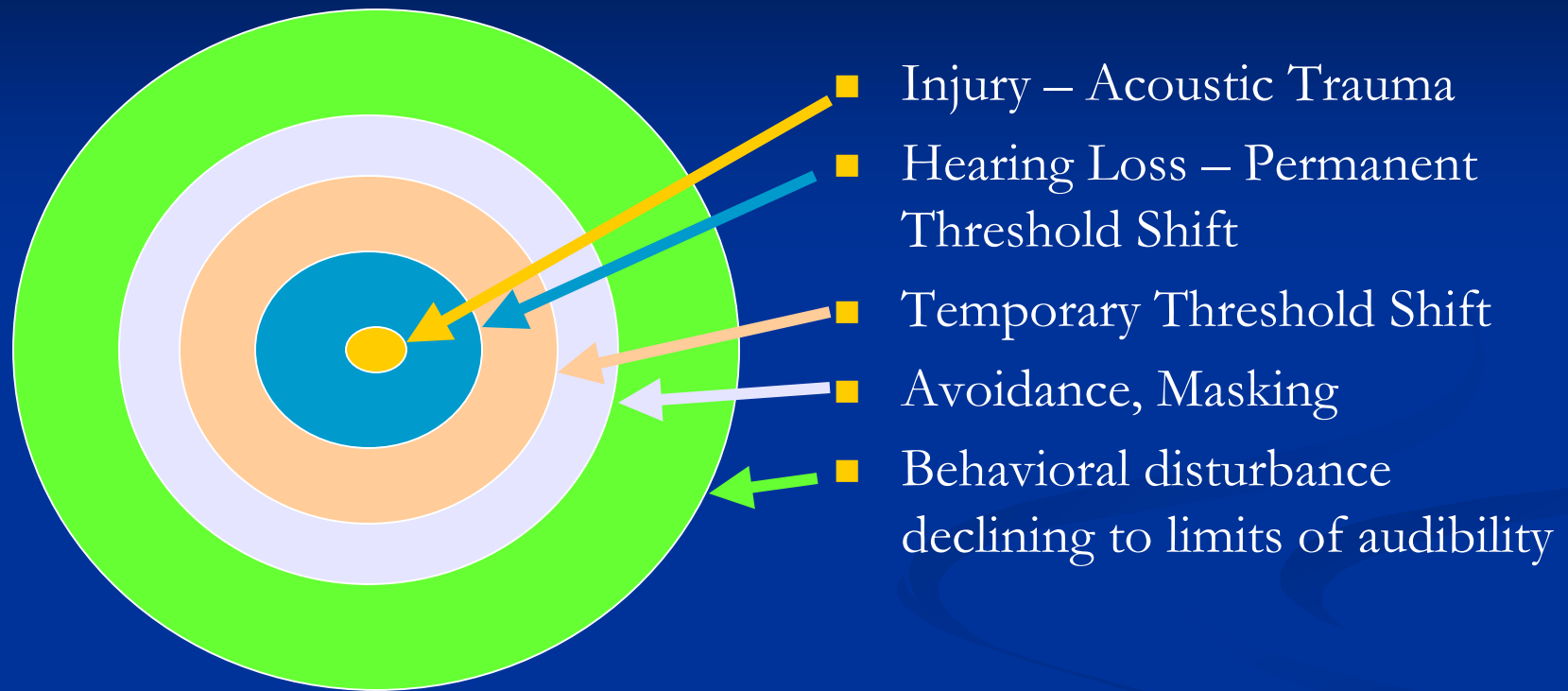
Meet with a 95% probability the following management goals based upon the Marine Mammal Protection Act

- Healthy populations will remain above the Optimal Sustainable Population (OSP) numbers over the next 20 years.
- Recovering populations will reach OSP numbers after 100 years.
- The recovery of populations at high risk will not be delayed in reaching OSP numbers by more than 10% beyond the time predicted with no human-induced mortality.

# Extension of PBR

- If PBR is to address cumulative impacts, it cannot be limited to fisheries nor to mortality and serious injury
- Include mortalities outside of fisheries; there has already been a slight extension to include ship strike mortalities in Northern right whales
- Equate sublethal effects on multiple animals to one “take” under PBR using a Severity Index which is the fractional take experienced by one animal
- Potential sublethal effects with respect to noise can be derived from zones of influence

# Zones of Noise Influence



Adapted from  
Richardson and  
Malme 1995

# Injury Take Equivalents

Based on NOAA's Visible Injury list:

- Loss or damage to an appendage, jaw, or eye. These injuries affect the long term ability of an animal to swim, feed, or see. (Severity Index of 0.3)
- Entanglement in fishing gear. It may take days or weeks for an animal to free from a serious entanglement, which may also leave long term injuries. (Severity Index of 0.1)
- Bleeding, lacerations, swelling or hemorrhage: While some of these symptoms may reflect a serious injury, they often will resolve in a few days with little long term consequences. (Severity Index of 0.01)



# Behavioral Take Equivalents

## Assumptions:

- The primary effects of harassment involve the loss of opportunities, time, and energy.
- If the proposed activity occurs at a critical time or in a critical place when a specific activity must occur (e.g., disrupts a critical feeding trip of a phocid seal or disturbs a breeding site during a short season), then the severity index will be higher.



# Behavioral Take Equivalents

- For an individual expected to have in excess of 10 breeding seasons, the severity of loss of a breeding season might be set to 0.1; if in excess of 30 breeding seasons, the severity of loss of a breeding season might be set to 0.03.

# Behavioral Take Equivalents

- Significant behavioral ecology modes, e.g., feeding, breeding, migrating, etc. often occur on a cycle approximating 100 days
- If normal activity were disturbed for 2.4 hours (1/10 of a day), the Severity Index would be 0.1/100 or 0.001
- If the disturbance lasted only minutes, then the Severity Index might be 0.0003

# Behavioral Take Equivalents

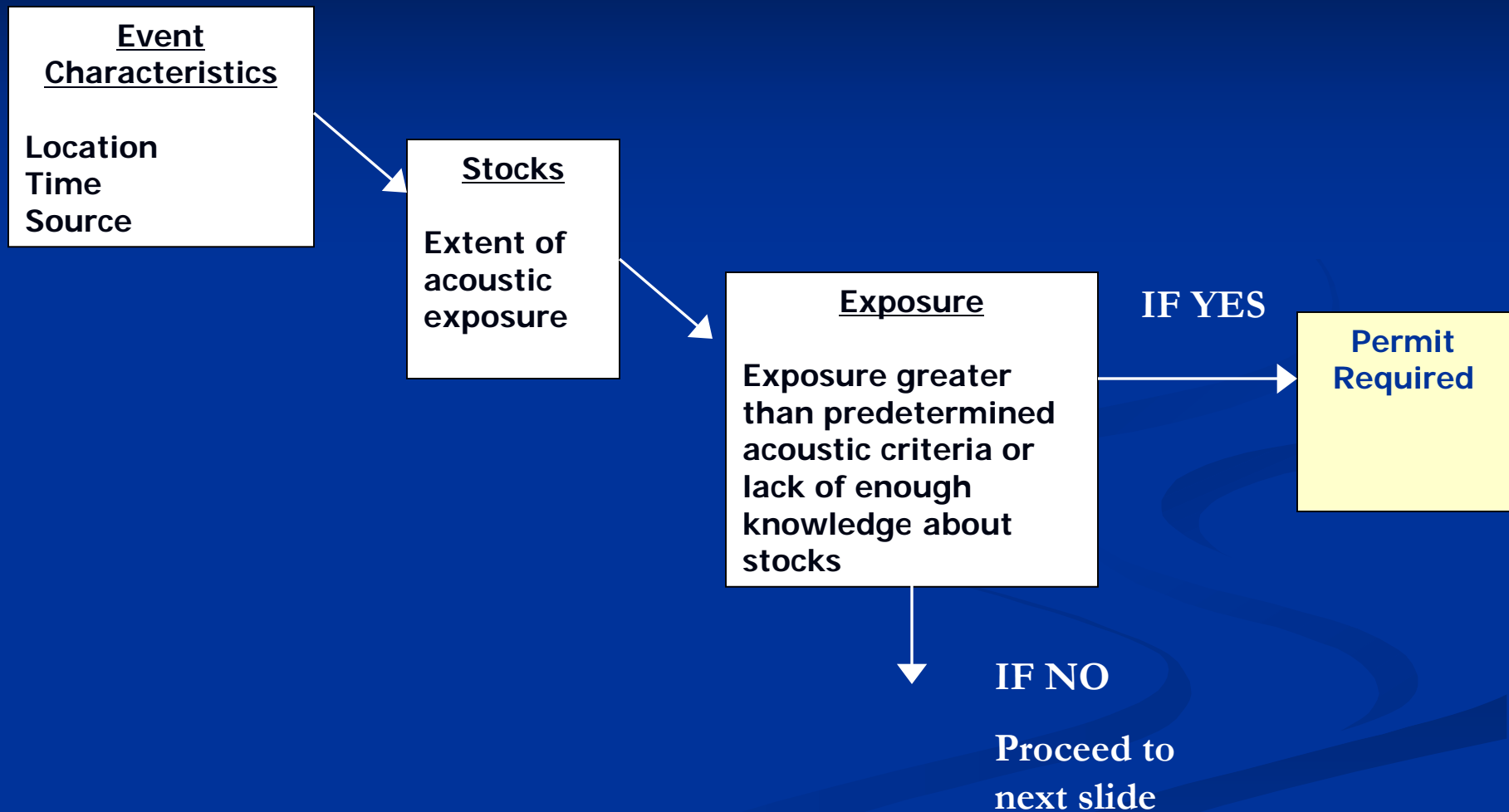
Effect	Range (m)	Severity (S)	Relative Area ( $\pi r^2$ )	Number of Animals (N)	(N)*(S)
Death or Serious Injury	1	1	3	1	1
Injury (e.g., hearing loss)	10	0.01	314	100	1
Behavioral Disturbance	100	0.0001	31,400	10,000	1

# RECOMMENDATION 7

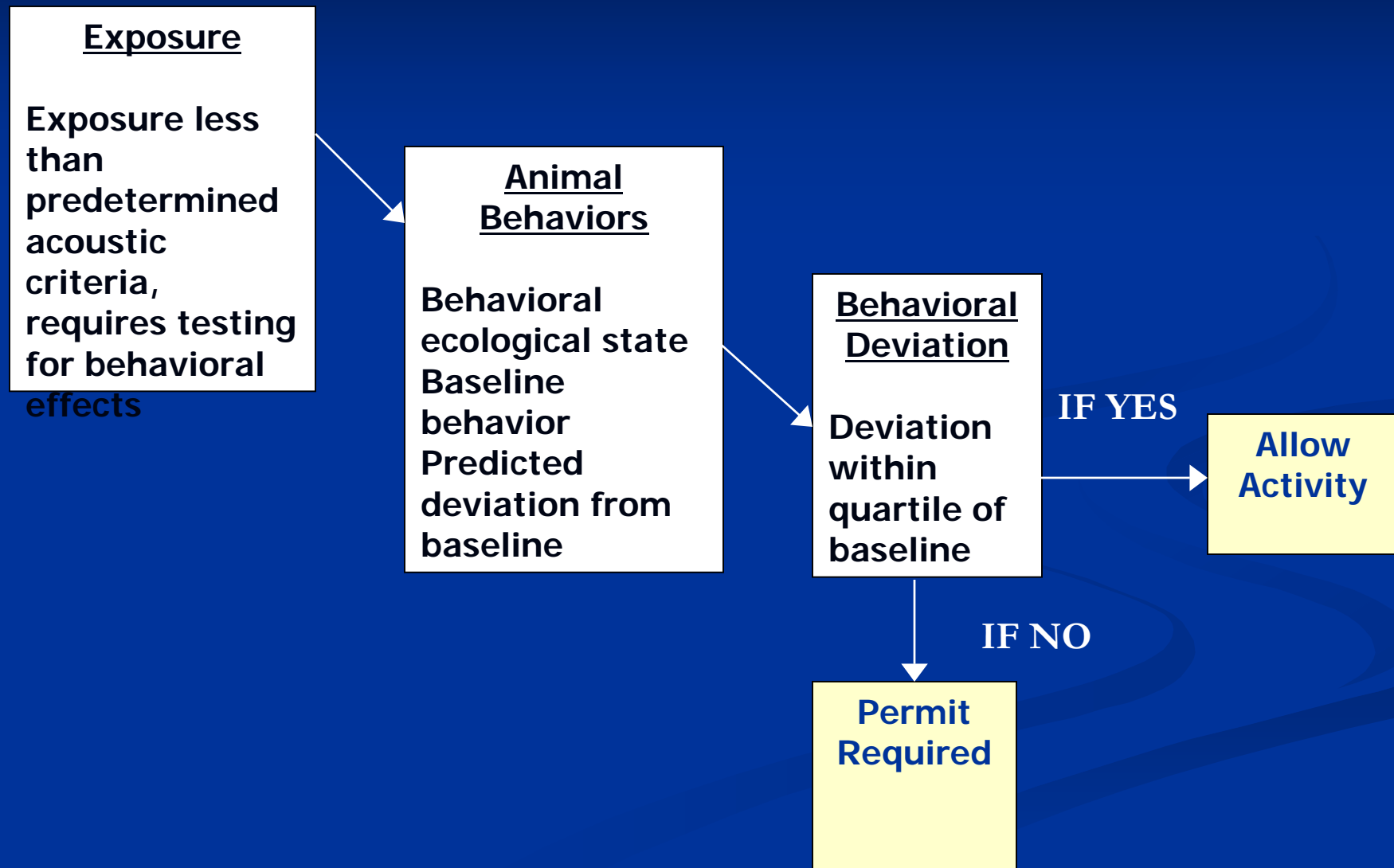
Improvements to PBR are needed to reflect total mortality losses and other cumulative impacts more accurately:

- NOAA Fisheries should devise a revised PBR regime in which all sources of mortality and serious injury can be authorized, monitored, regulated, and reported in much the same manner as is currently done by commercial fisheries under Section 118 of the MMPA.
- NOAA Fisheries should expand the PBR model to include injury and behavioral disturbance with appropriate weighting factors for severity of injury or significance of behavioral response (cf. NRC, 1994, p. 35).

# Web-based Intelligent System



# Web-based Intelligent System



# Exposure – Acoustic Criteria

- Use NOAA Fisheries matrix
  - Five functional groups: low-, mid-, and high-frequency cetaceans; pinnipeds in water and in air
  - Four sound types: single and multiple pulses; single and multiple non-pulses
  - Sound Pressure Level (rms or peak) or energy flux density exceeds Permanent Threshold Shift level
  - Forty cells in matrix

# Exposure – Behavioral Criteria

- Migration - neither the path length nor the duration of migration could be increased into the upper quartile of the normal time or distance of migration
- Breeding - disruption of male behavior should not reduce the pool of potential mates from which a female can choose by more than 25%
- Lactation - disturbance should not reduce the nutrition from lactation to less than the lower quartile of normal



# RECOMMENDATION 8

An intelligent-decision system should be developed to determine a *de minimis* standard for allowing proposed sound-related activities.

An expert-opinion panel should be constituted to populate the proposed system with as many decision points as current information and expert opinion allow.

The system should be systematically reviewed and updated regularly.

# Three Stage Approach

- **Within a year:** Development of web-based intelligent system to determine a *de minimis* threshold below which impacts of activities are clearly not significant
- **Several years:** Extension of the Potential Biological Removal Model to include sub-lethal “takes” from noise
- **Decade(s):** Transform Conceptual Model into a Predictive Model for significance of effects of noise on marine mammals